An evaluation of the potential of humates in the reduction of ammonia volatilization

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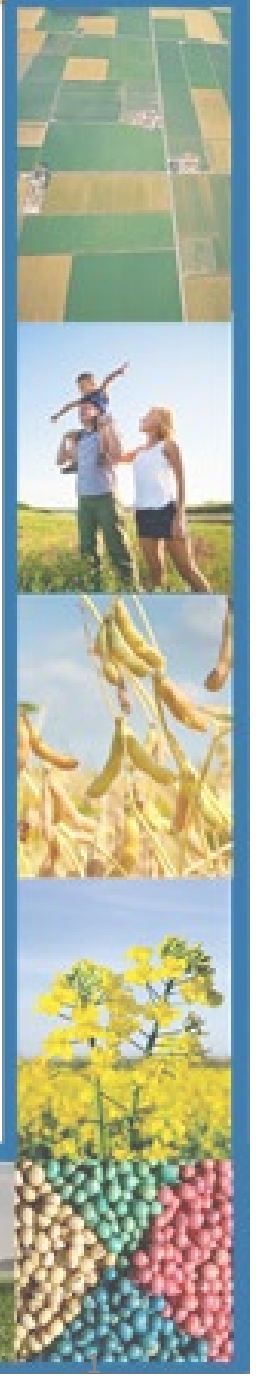

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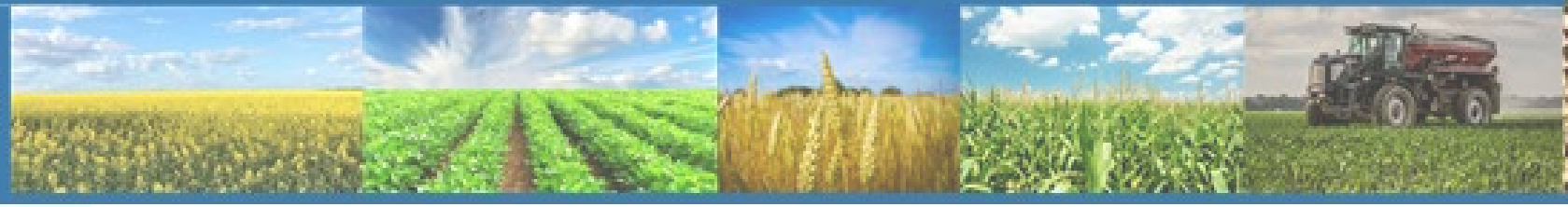
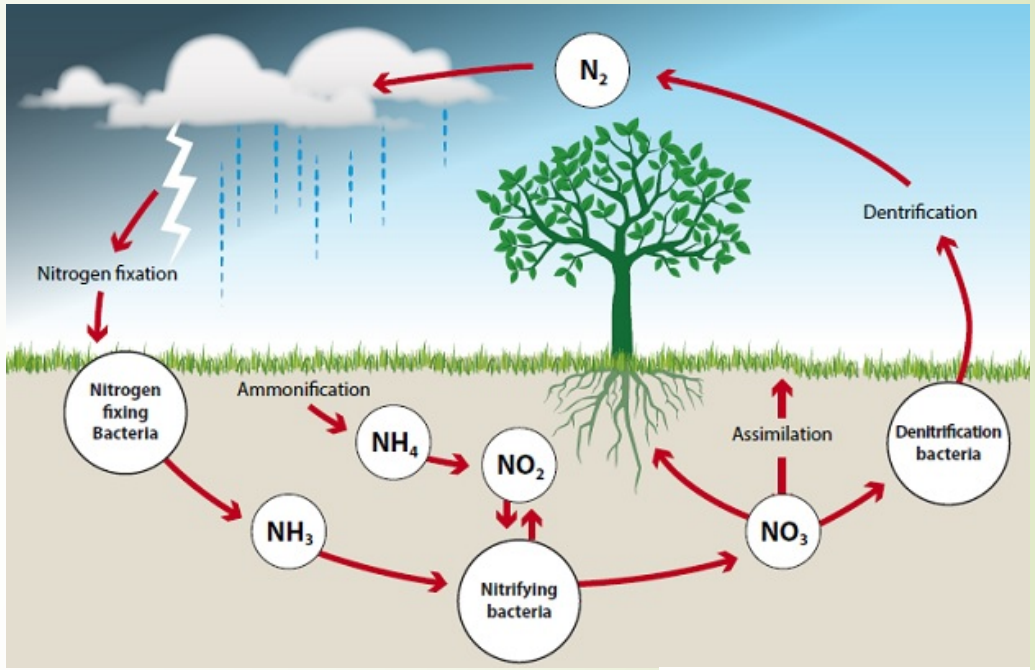


"Everything you see exists together in a delicate balance. As king, you need to understand that balance and respect all the creatures, from the crawling ant to the leaping antelope."

- Mufasa

Image: https://ohmy.disney.com/

- The processes that produce plant-available nitrogen are biologically mediated
- We must find solutions to minimize losses



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- Urea-based nitrogen fertilizer products are susceptible to ammonia volatilization

- $(NH_2)_2CO + H_2O \xrightarrow{\text{urease}} NH_3 + H_2NCOOH \rightarrow 2NH_{3(gas)} + CO_{2(gas)}$

- $NH_3 + H_20 \rightarrow NH_4^+ + OH^-$

- Ammonia volatilization leads to agricultural losses

Image: https://homeguides.sfgate.com/

Problem

- Urease inhibitors can limit urea hydrolysis for between 7 to 14 days, after which rain, irrigation, or soil mixing would be needed to reduce ammonia volatilization
- But what happens when there is no rain?
- Are there other alternatives?
- $NH_3 + H_20 \rightarrow NH_4^+ + OH^-$
- Perhaps something with a high CEC and/or causes a reduction in pH could reduce ammonia volatilization?

- Humates have been shown to have very high CEC and AEC
- They can be extracted from any material containing well-decomposed organic matter - soil, coal, composts, etc
- We tested the hypothesis that amending Urea Ammonium Nitrate (UAN) with a humate could reduce ammonia volatilization

Methodology

- Land near LeRoy, Sk
- Clay loam soil, pH 8
- Wheat seeded at 135 lbs/ac
- Nitrogen side banded 1.5" deep
- UAN at 90 lbs N/acre
- Treatments replicated thrice:

Untreated UAN

UAN + NBPT (N-(n-butyl) thiophosphoric triamide;1.6 litres per tonne of UAN)

UAN + humate (600 ml of humate per 76 litres of UAN)

- Other fertilizers: Urea 65 lbs/ac, MAP 73 lbs/ac, KCl 40 lbs/ac

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ARTICLE

Development of a simple and affordable method of measuring ammonia volatilization from land applied manures

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Abstract: Quantifying ammonia (NH_3) flux following fertilizer and manure nitrogen (N) application is crucial to develop sound management practices. Traditional methods used for obtaining these measures are expensive, inefficient, or inaccurate. The objective of this study is to develop a method using a passive dosimeter and a semi-open static chamber to provide an economical and simple solution to measure NH_3 loss following nitrogen application. Dosimeter tubes were commercially developed to measure ammonia exposure, providing a time-weighted average. In this study, chicken manure was applied to short grass and the ppm h reading obtained using the dositube ammonia method was calibrated against a reference measure of NH_3 loss (kg N ha^{-1}) using a wind tunnel and acid trap method. A calibration was developed (Estimated Total Loss (kg N ha^{-1}) = (0.217*Dw*) – (0.034*D*) + 0.71), which requires the dositube (*D*, ppm h) to be read every 24 h and placed at a height of 0.15 m in the dositube chamber, with wind speed (*w*, m s^{-1}) measured at a height of 0.3 m and averaged over the coinciding time period. This calibration may also be applied where dositubes are read every 48 h; however, 24 h periods are recommended to achieve the greatest accuracy.

Key words: ammonia volatilization, dositube ammonia method, semi-open static chambers, calibration.

Résumé : Pour élaborer des pratiques de gestion valables, on doit absolument quantifier le flux d'ammoniac (NH_3) consécutif à l'application d'azote (N) sous forme d'engrais chimique ou de fumier. Toutefois, les méthodes usuelles pour le faire sont dispendieuses et manquent d'efficacité ou de précision. Les auteurs voulaient élaborer une méthode reposant sur l'usage d'un dosimètre passif et d'une chambre statique semi-ouverte avec laquelle on quantifierait simplement et de façon économique les pertes de NH_3 après l'application d'azote. À cette fin, ils ont développé commercialement des éprouvettes dosimétriques ou Dositubes qui mesurent l'exposition à l'ammoniac et en donnent une moyenne pondérée dans le temps. Dans le cadre de cette étude, ils ont appliqué du fumier de poulet sur de l'herbe rase et ont étalonné le nombre de ppm par heure établi avec les Dositubes d'ammoniac (DA) d'après les pertes de NH_3 (kg de N par hectare) mesurées dans une soufflerie et avec une technique de piégeage à l'acide. Les auteurs ont ainsi mis au point une formule [perte estimative totale (kg de N par ha) = (0,217*Dw*) – (0,034*D*) + 0,71] en vertu de laquelle on procède à une lecture des Dositubes (*D*, ppm par heure) toutes les 24 h, à une hauteur de 0,15 m dans la chambre du dositube. La vitesse moyenne du vent (*w*, en m par seconde) est déterminée à 0,3 m de hauteur, pour une période équivalente. Les relevés peuvent aussi être effectués aux 48 h

Dosimeter tubes (#3D, Gastec Corporation, Japan) measure ammonia exposure

The dositube contains purple packing material (sulphuric acid) that turns yellow when it reacts with ammonia (becoming ammonium sulphate)

The scale shows the concentration of NH_3 over time(ppm hr^{-1})

Tubes are suspended on a stake at a height of 0.15 m above the soil surface

Covered up with a semi-open static chamber immediately after N application

- a round pail with a height of about 26.5 cm and an inner diameter of 19 cm
- Eight 1.27-cm-diameter (1/2 inch) holes were drilled into the top of the pail, and eight 1.27-cm-diameter holes were drilled 4 cm from the bottom of the pail

(Estimated Total Loss (kg N ha^{-1}) = (0.217Dw) − (0.034D) + 0.71)

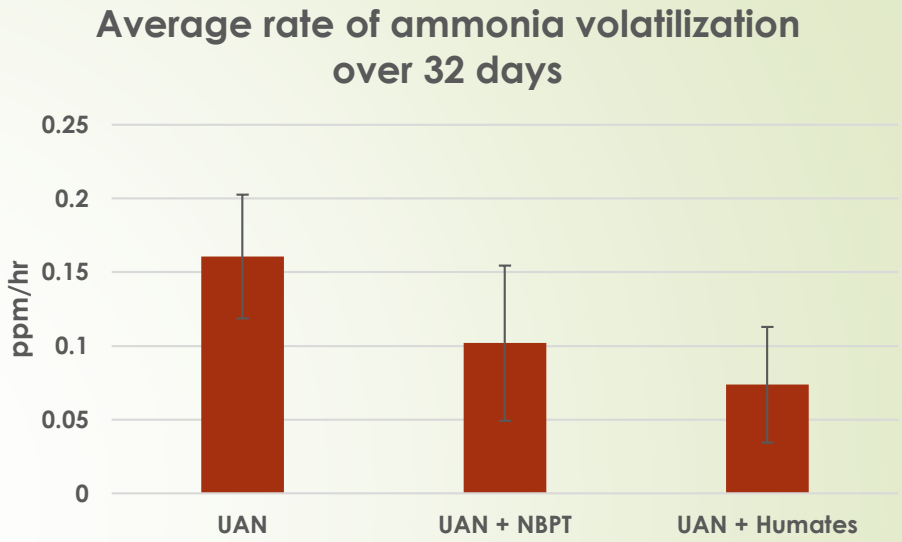
Where D = Dosimeter reading

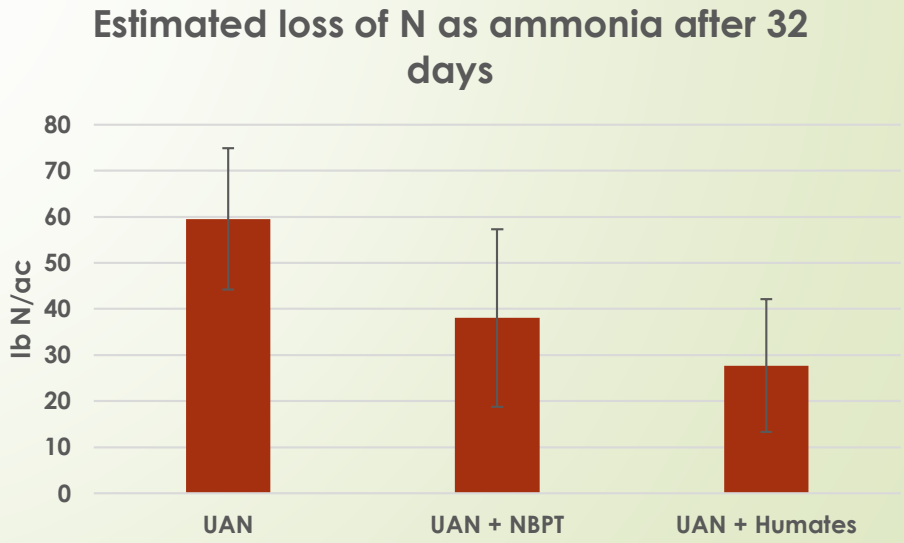
W = wind speed

(w, m s^{-1}) measured at a height of 0.3 m and averaged over the coinciding time period

Results and discussion

- Ammonia volatilization was slow for the first 2 weeks (nothing was picked up in the dositubes)
- Land received no rain





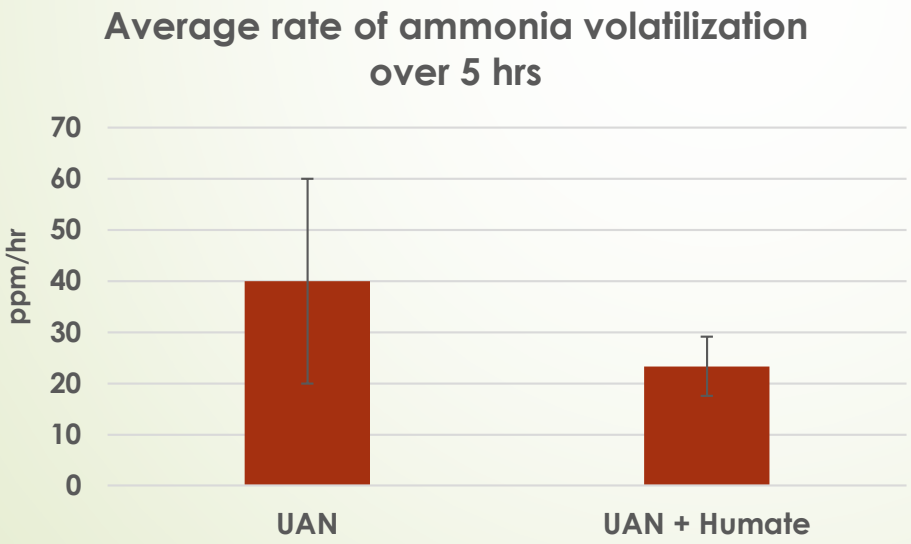
- ***Any story worth telling is worth telling twice***
  - *Rafiki*

Image: disney.fandom.com

Laboratory experiment

- 1 kg of soil (pH 7.03)
- Same rate of humate as in the field (600 ml of humate per 76 litres of UAN)
- Applied 1 ml of UAN (or UAN + humate); 3 reps
- Moistened to about 60% of field capacity

- Containers were fit with dositubes and covered
- Monitored for 5 hours



What is the mechanism?

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Effect of humic acid on ammonia volatilization from some calcareous soils

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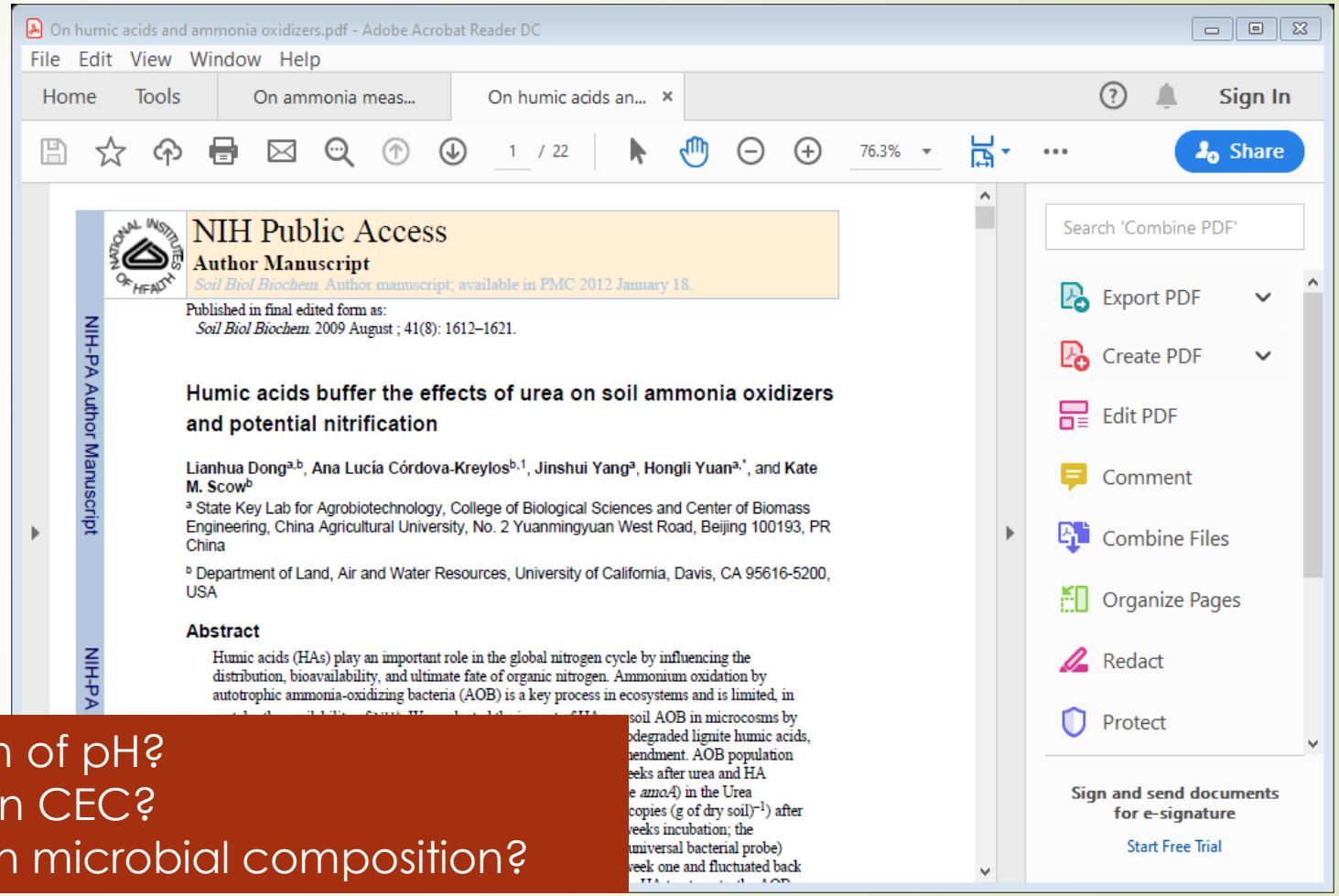
Abstract. The objectives of this study were to compare the effect of three rates of humic acid (0, 2.5 and 5.0 g kg^{-1} soil) and N-urea (0, 60 and 120 mg N kg^{-1} soil) and mixtures of them on NH_3 loss (volatilization) from two calcareous soils (Abul-Khasseb, silty clay soil, and Zubair, loamy sand soil). The use of humic acid significantly reduced NH_3 loss and increased exchangeable NH_4^+ in both studied soils. The high total acidity of humic acid made the treatment the best in reducing N loss after incubation. Zubair soil showed more N loss than Abul-Khasseb soil due to their physical and chemical characteristics. The soil content of NH_4^+ and NO_3^- increased significantly in both studied soils with increasing N rates. It can conclude that, humic acid, in general have great ability in controlling NH_3 loss and retaining NH_4^+ in calcareous soils. It could be an economical efficient, practical and easiest way to control N loss.
Key Words: N-urea, N loss, urea fertilizer, ammonium, nitrate.

Introduction. Ammonia volatilization is a major pathway for N loss from surface-applied urea (Cai et al 2002; Prasertsak et al 2001). Volatilization losses can occur in calcareous soils due to high pH and NH_4^+ in the microsite where urea granules are dissolved and hydrolyzed (Siva et al 1999; Fan & Mackenzie 1993). Under normal conditions ammonium (NH_4^+), hydroxyl (OH^-) and carbonate (CO_3^-) ions are produced rapidly (1 or 2 days) after surface application of urea by urease (Zhengping et al 1991). This leads to the accumulation of NH_4^+ which simultaneously increases the soil pH surrounding the application area or near the urea granule (Zaman et al 2007). The increase of OH^-, HCO_3^- and NH_4^+ concentrations through this process plays a significant role in the rapid loss of nitrogen.

There are many factors involved in NH_3 volatilization, which can be grouped into soil (e.g. pH, CEC), environment (e.g. temperature, humidity) and management (e.g. surface application of fertilizer, drilling). A number of studied with diffe
has reduced NH_3 losses (Fan & Mackenzie 1993; Al-Kanani et al 1990;
Katyal 1998; Zaman et al 2007). Acidic materials alone, organic and ino
mixture of acidic materials and additives could reduce N losses by 60,
respectively (Lethbride & Burns 1976; Al-Kanani et al 1990; Fan & M
Zaman et al 2007).

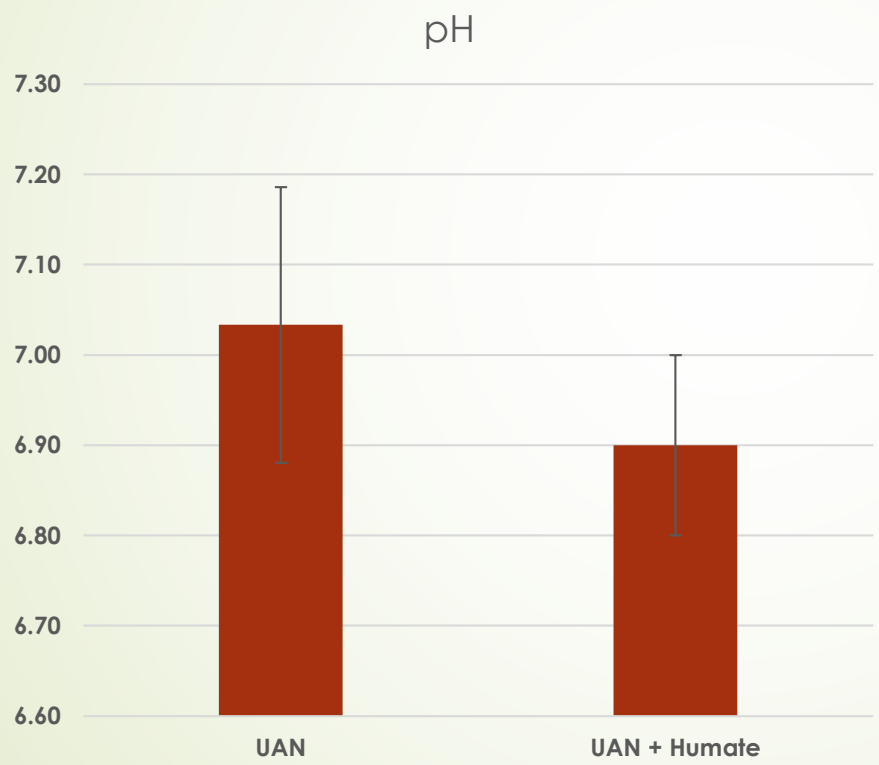
In some studies, acidic materials such as humic acid and triple s
have been used to reduce ammonia loss from surface applied urea (F
1993; Ahmed et al 2006). These acidic materials lower the soil microsite
around the fertilizer, reduce the hydrolysis of urea thus reducing the
Humic acid has high total acidity (CEC) aid to retain NH_4^+ and NO_3^- whi
useable from of nitrogen (Fan & Mackenzie 1993; Ahmed et al 2006).
this study was to evaluate the effectiveness of humic acid in reducing N loss from urea fertilizer added to two calcareous soils as well as to investigate the ability of humic acid to retain NH_4^+, or reduce soil pH.

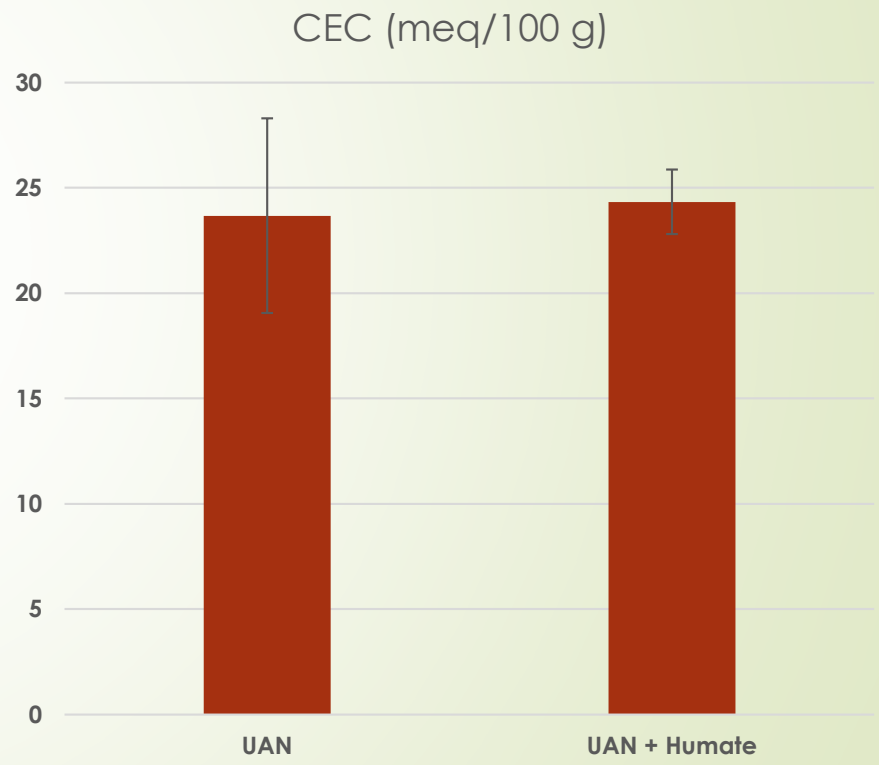
Material and Method. The study was conducted on two calcareous soils from Basrah governorate (Abul-Khasseb and Zubair-Barjesia). The soil samples taken at 0 – 30 cm depth were air dried and ground to pass 2 mm sieve. The selected chemical and physical



Reduction of pH?
Increase in CEC?
Change in microbial composition?

pH and CEC of experimental soils





Conclusions and recommendations

- Ammonia volatilization can put crops behind early in the season
- Amending urea-based fertilizers with humic substances may provide some benefit
- Mechanisms need to be further studied
- Effect on nitrate leaching needs to be evaluated

"You got to put your behind in your past" - Pumbaa

Image: disney.fandom.com

Thank you!

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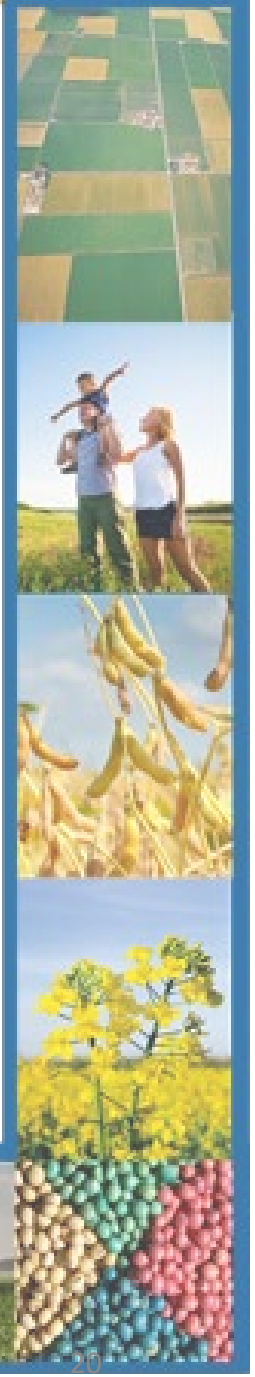

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